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BATHYMETRIC AND OCEANOGRAPHIC SURVEY OF THE SANTA LUCIA BANK (A SMALL SEAMOUNT IN THE LIGURIAN SEA)

by

DAVID H. SHONTING, CARLO BARTOLINI, and GIULIANO TOGNARINI

15 OCTOBER 1970

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TECHNICAL MEMORANDUM NO.157

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APPROVED FOR DISTRIBUTION

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Director

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ABSTRACT

A bathymetric and oceanographic survey was made of the Santa Lucia Bank, a small seamount in the northeastern Ligurian Sea having a minimum depth of 125-130 m. A three-day observation of currents at its crest shows a steady average flow of about 23 cm/s to the west and west-south-west. Analysis of a grab sample of the debris on the bank showed that it was apparently the product of beach erosion and that the seamount had neen uncovered within the past 7-8 million years. Many fish, observed on the echo sounder as strong individual and collective scatterers, were generally present around the crest of the seamount. The Bank appears to have valuable potential as a submerged platform near La Spezia on which to anchor ships and buoys to make sea/air interaction, oceanographic, and acoustic observations.

INTRODUCTION

The oceanographic research programme at SACLANTCEN includes studies of oceanic variability and sea/air interaction. These often necessitate anchoring a research vessel to make time-series records of oceanographic or acoustic parameters to be monitored from instruments aboard ship or on tethered or anchored buoys.

Santa Lucia Bank [Fig. 1] is easily reached from La Spezia and seemed a suitable place to anchor for such purposes, since its minimum depth was indicated as 125 m [Ref. 1] and it is surrounded by relatively deep water (600 m - 1000 m). Being 58 km from the Italian mainland, the area should be reasonably typical of open sea conditions and also be relatively free from local effects of mountain ranges on the gross wind field. Similarly, the water circulation in the region should be relatively free from shoal or land boundary effects (except, of course, that the Bank itself might affect the current passing over it and possibly disturb the local distribution of oceanographic variables).

The following is a description of the attributes of the Santa Lucia Bank obtained from a brief study of its bathymetry, geology, and oceanographic environment.

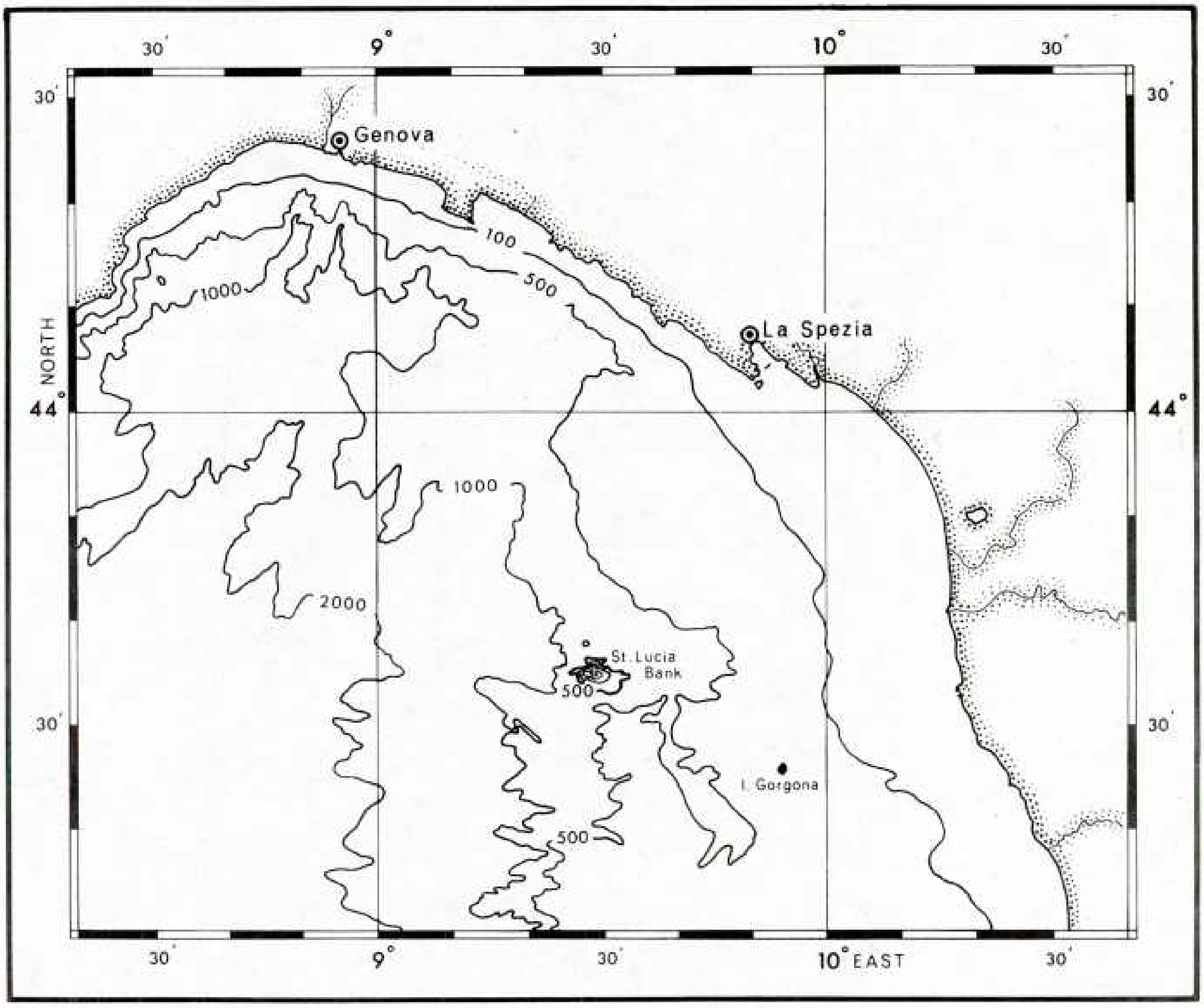

FIG. 1 THE NORTHEAST LIGURIAN SEA SHOWING THE SANTA LUCIA BANK
(Taken from Carta Numero 1250 of Ref. 1)

1. THE BATHYMETRY

Two bathymetric surveys of the Santa Lucia Bank were made during March 1969 and March 1970 using a Raytheon Precision Fathom Recorder aboard SACLANTCEN's research vessel MARIA PAOLINA. The track chart of the surveys is shown in Fig. 2. Navigation controls were provided by two short-scope radar marker buoys moored on the bank and by loran-C. A large scale loran-C chart was prepared especially for the survey. Every five minutes during the bathymetric survey, ranges and bearings were taken on the marker buoys and a loran-C fix was recorded.

The loran-C performed excellently during the survey and when fixes were made on the anchored marker buoys their positions were repeatable to within a plotted position of 50 m to 75 m — the maximum accuracy obtainable by loran-C in the Ligurian Sea. This navigational accuracy was borne out by the good agreement of the depths at the several track intersections.

In preparing the bathymetric chart [Fig. 3], in the region outside the 400 m isobath, the depth contouring was done on sections at 300 m horizontal increments (indicated by dashed lines at the bottom right-hand side of the track). Near the crest of the Bank the depth values were picked off the tracks at about 50 m horizontal intervals.

The bathymetry [Fig. 3] reveals a small east-west elongated seamount that rises from the zone between the Ligurian Basin and the shallow coastal shelf [see Fig. 1]. It slopes down to depths of from 600 m to 700 m on the north, east, and south sides, but slopes rapidly to over 1000 m on the western apron, which is adjacent to a gradually deepening zone falling away to the 2500 m deep Ligurian Basin.

The Bank is steep-walled, particularly on its southwest side [Fig. 3] where the slope approaches 40° between the 800 m and 500 m isobaths. Section A [Fig. 2] made across the north-east corner of the bank shows the steep and relatively smooth sides rising from the deeper shelf-slope region [Fig. 4].

Above the 300 m isobath the topography flattens out to form a plateau-like area about 7 km long (east-west) and from 1 km to 2 km in width that slopes upwards at 3° to 10° to the crest at the eastern end. This crest is delineated by the 180 m isobath [Fig. 3], which in turn contains two shallower regions within the 160 m isobath. The northern shallow region contains several steep pinnacles with slopes of up to 30° to 40°, one of which is shown rising from a 155 m terrace in Fig. 5; 133 m is the shallowest depth observed. The southern shallow region contains one isolated peak with a minimum depth of about 146 m (shown by Sections B and D in Figs. 6 and 7].

It should be noted that from the data obtained during the first survey (March 1969) a minimum depth of 143 m was observed. Since this was substantially deeper than the minimum depth of 125 m recorded on the Italian chart [Ref. 1], two additional bathymetric profiles were made across the crest of the Bank in March 1970. One profile [D in Fig. 7] made during this survey showed a minimum depth of 133 m. However, side echoes are seen on this profile, and as other profiles also show side echoes that could be attributed to shallower steep pinnacles it is assumed that, within the limits of accuracy, the reported 125 m minimum depth is probably valid.

That the top of the Bank is essentially bare rock was indicated by the fact that the ship had great difficulty in holding its moorings on a slope of one in three or four, even with its 2-ton Stimson-type anchor. Winds of less than 8 m/s were sufficient to cause the ship to drag its anchor off the Bank three times. Also, when the hard cast-iron anchor was retrieved it displayed severe scraping, and large chips (10 cm to 12 cm in length) had broken off, apparently as it was being dragged over the extremely hard surface on the crest of the Bank. It is clear that to anchor a ship or large buoy on the crest will require special equipment.

An indication of terracing, perhaps due to wave erosion when the Bank was partly uncovered, is seen in Fig. 6, which depicts an unusually flat region, about 700 m to 800 m wide, occurring at about 170 m to 175 m depth. Figure 5 also shows a terrace-like area at 150 m to 155 m depth surrounding a steep pinnacle.

It will be noted that the feature might more properly be termed a "seamount", although the Italian bathymetric charts refer to it as the Santa Lucia Bank. This, however, is not using the term "bank" in the usual sense of an extensive shallow or shelf area, such as Georges Bank or Browns Bank on the east coast of North America, which cover many thousands of square kilometres.

According to Heezen et al [Ref. 2] a seamount is defined as "any isolated elevation which rises more than 500 fathoms (915 m)". From Fig. 1 we see that the Santa Lucia Bank is indeed an isolated elevation and that to westward the bottom falls rapidly away to over 1000 m depth at a distance of 7 km to 8 km.

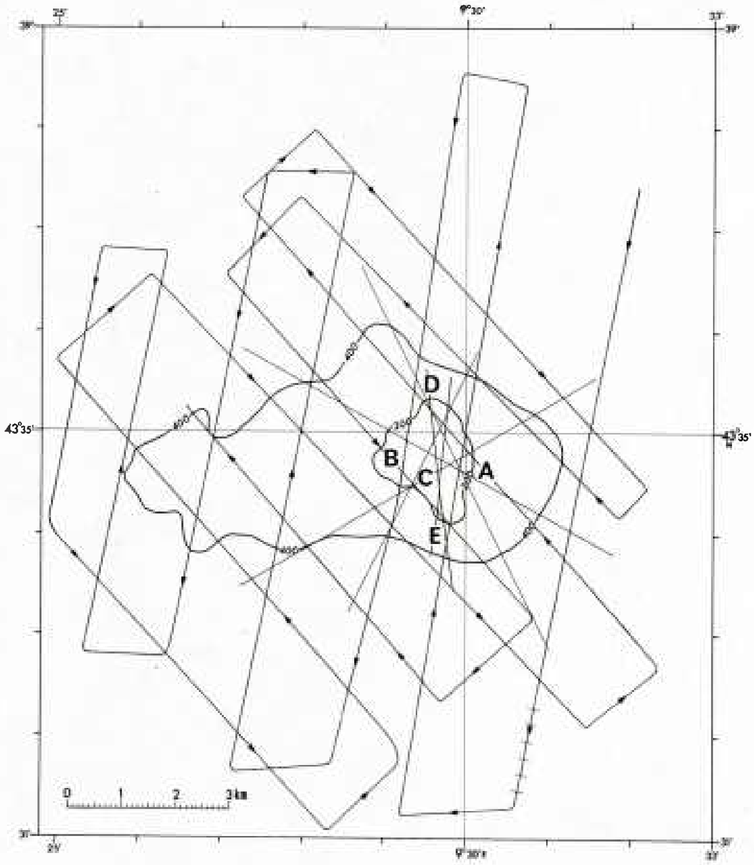

FIG. 2 THE TRACK CHART OF THE MARIA PAOLINA G. WHEN MAKING THE BATHYMETRIC SURVEY ON 27 MARCH 1969. These tracks include sections A, B, and C. Section D was made in March, 1970 in order to better establish the minimum depth.

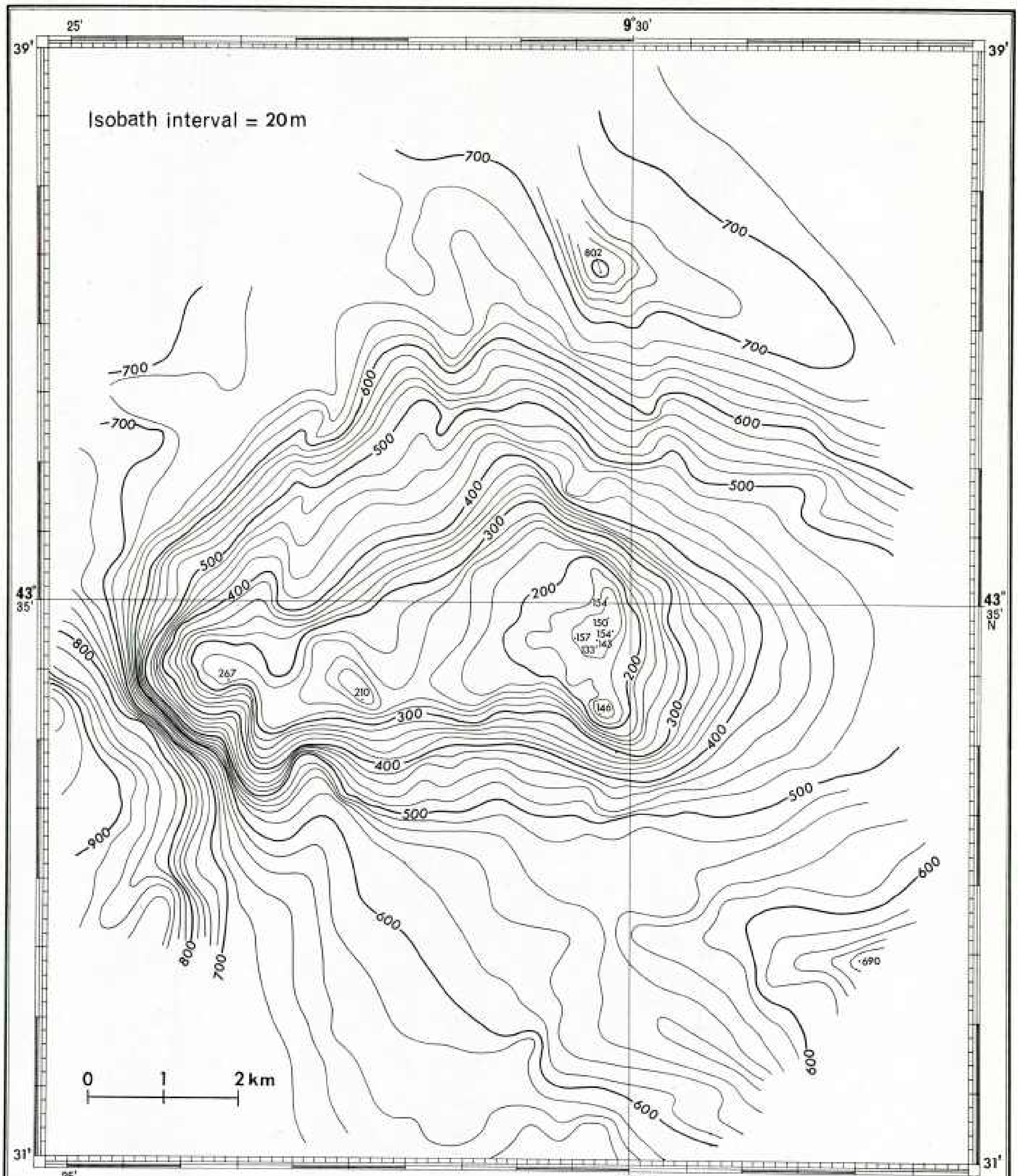

FIG. 3 BATHYMETRIC CHART OF THE SANTA LUCIA BANK

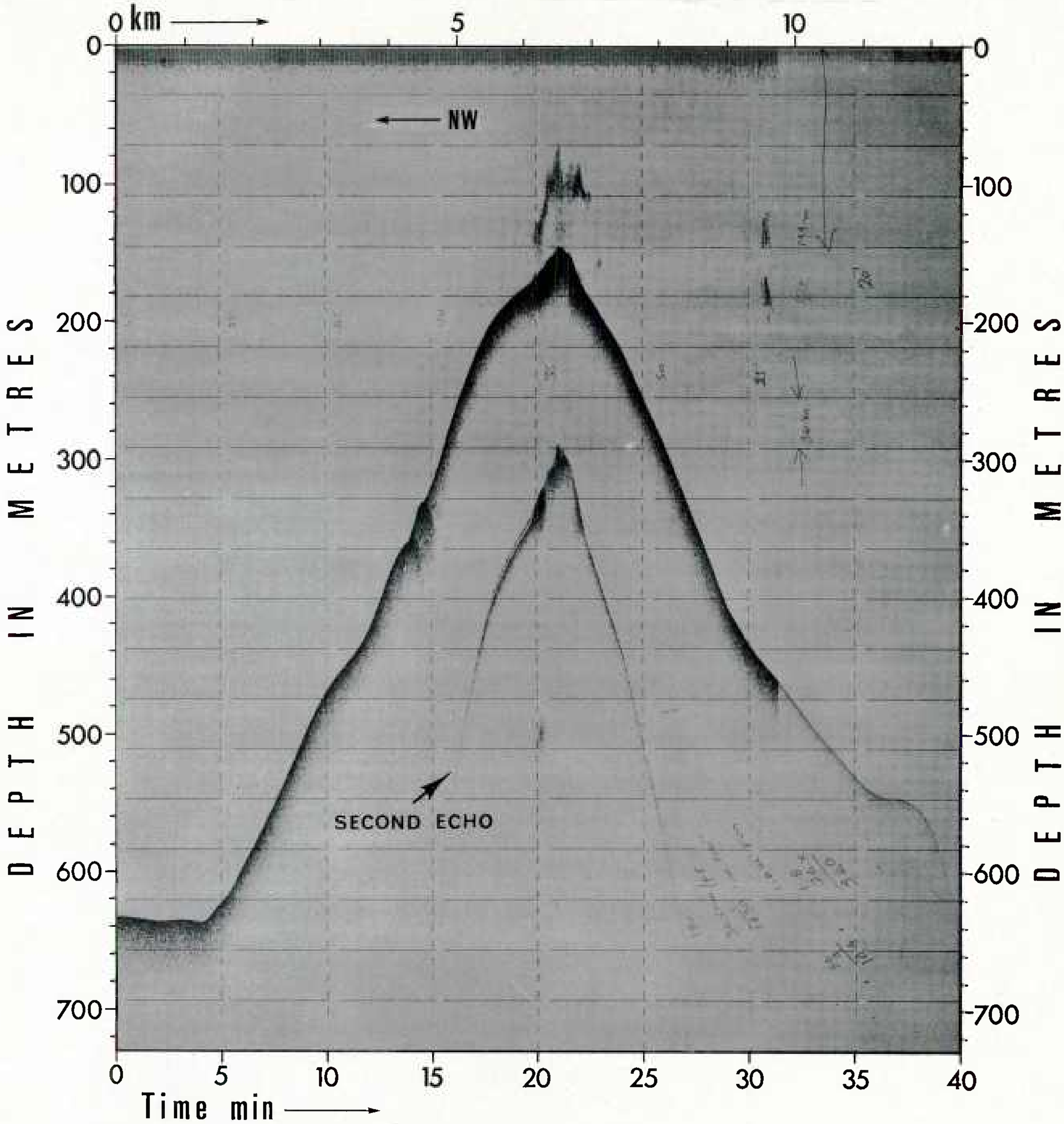

FIG. 4 ECHOGRAM OF SECTION A (see Fig. 2)

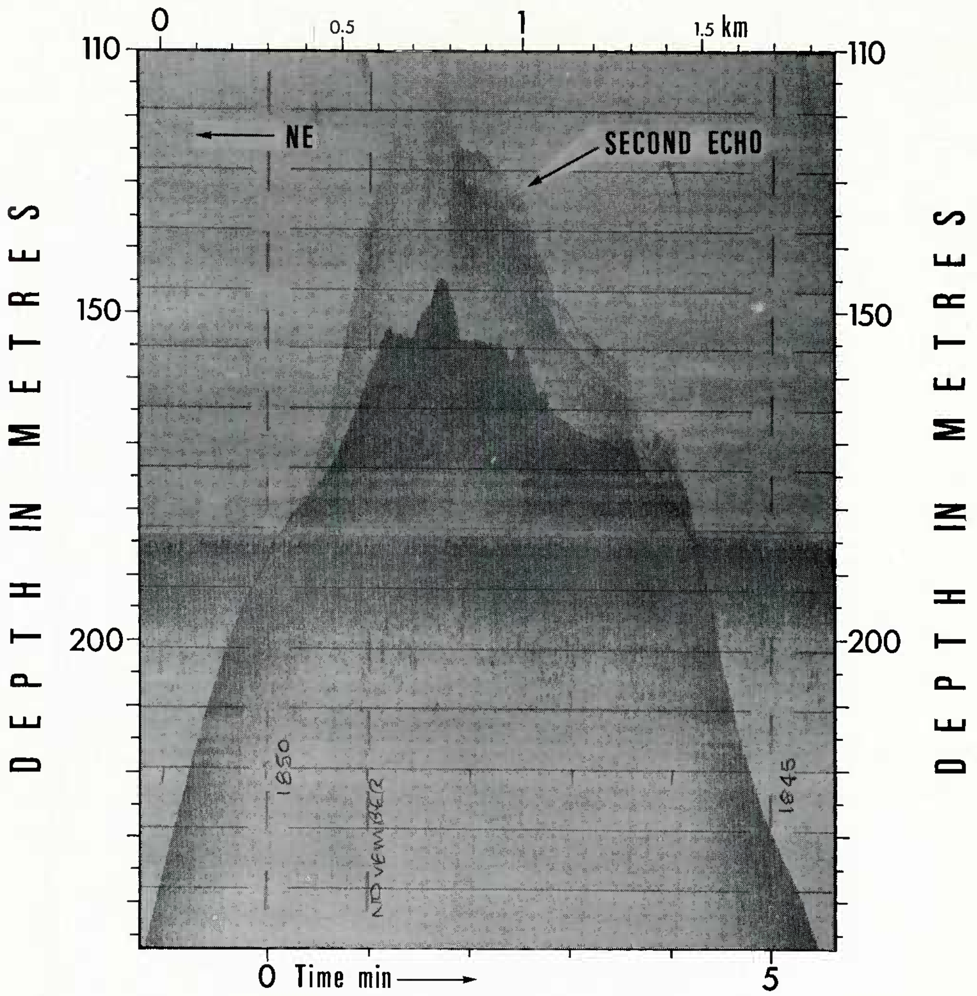

FIG. 5 ECHOGRAM OF SECTION C. Note the steep rocky pinnacles at the peak

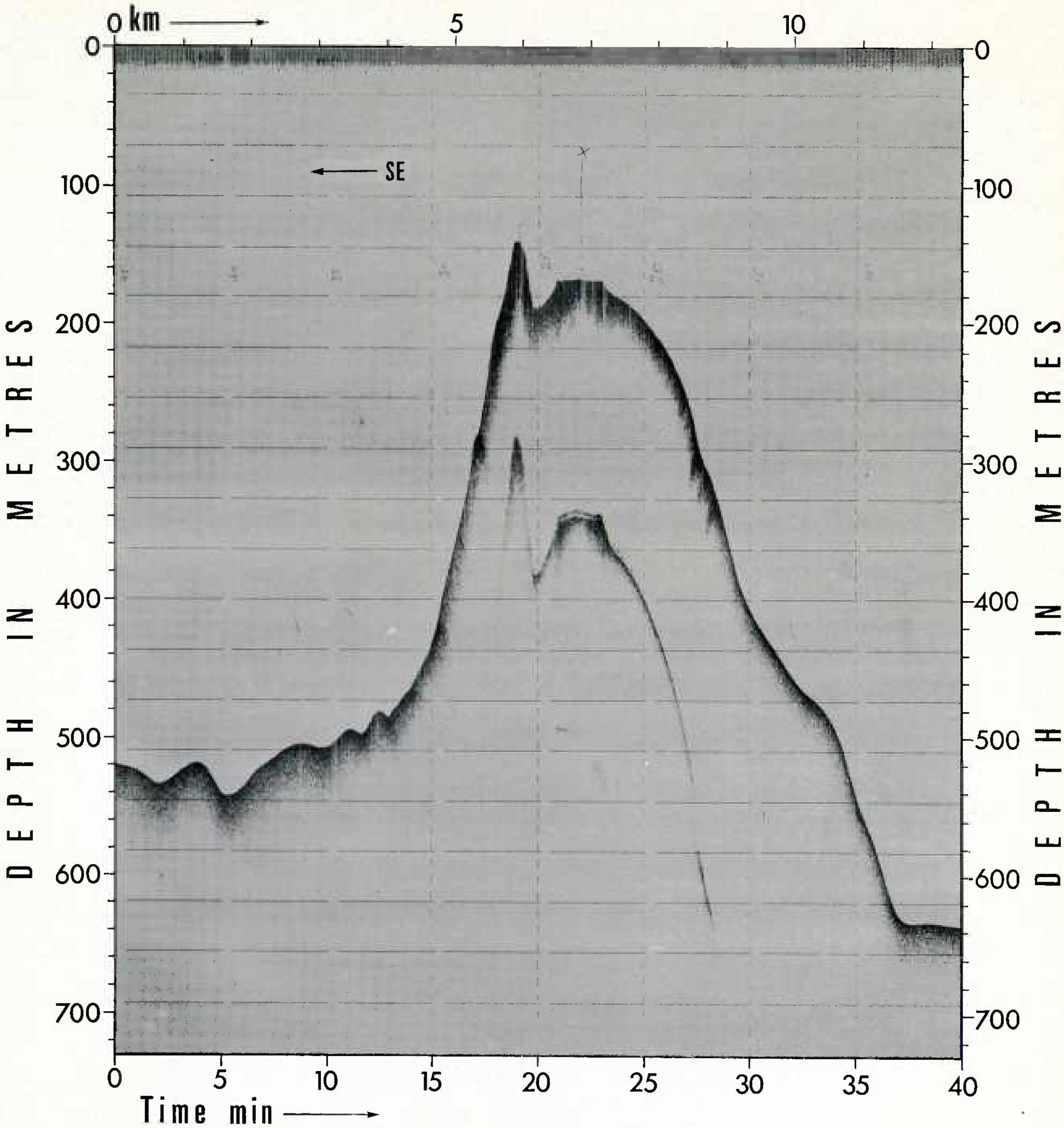

FIG. 6 ECHOGRAM OF SECTION B (see Fig. 2)

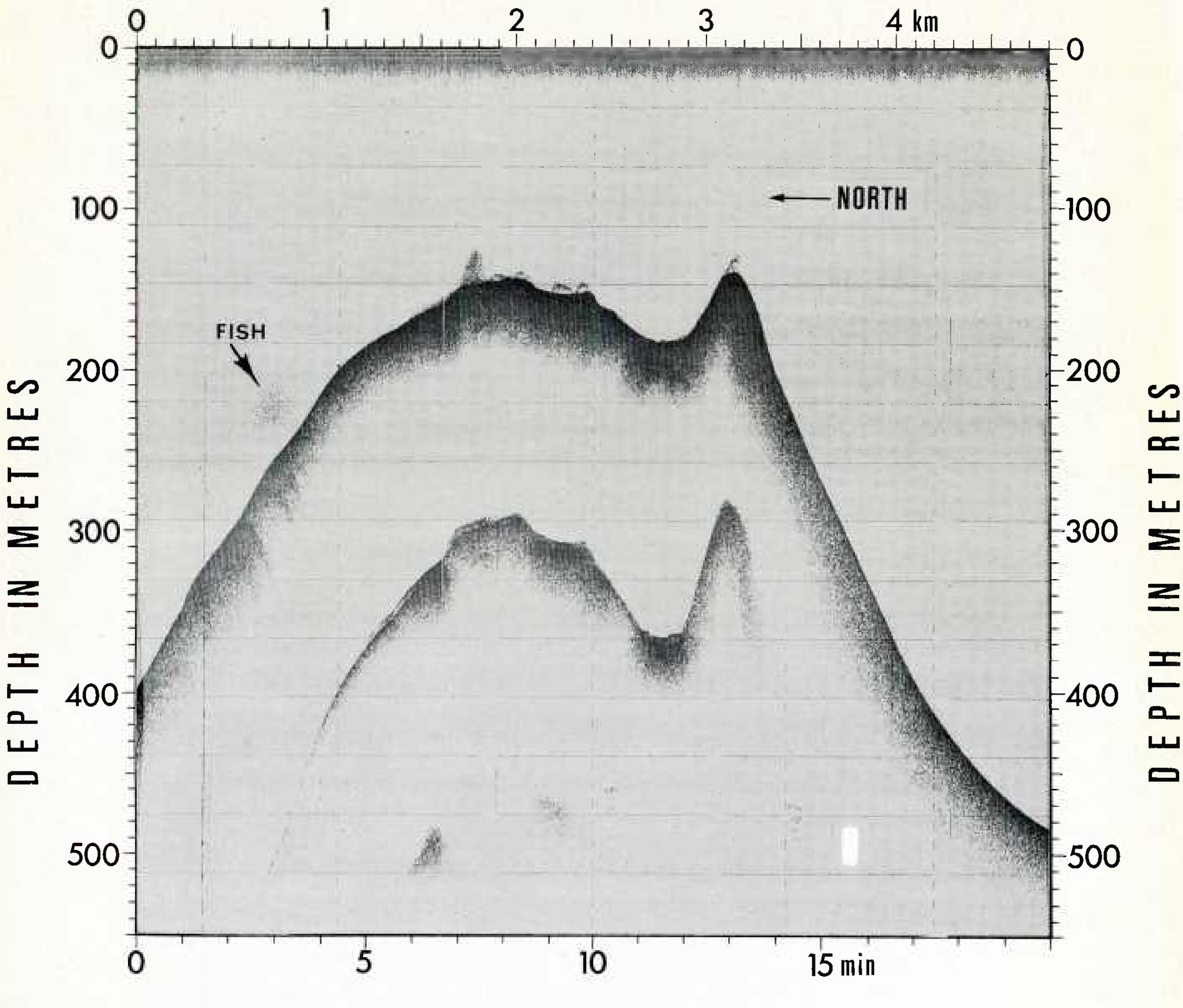

FIG. 7 ECHOGRAM OF SECTION D (see Fig. 2)

2. THE OCEANOGRAPHIC AND BIOLOGICAL ENVIRONMENT

During the three days that the ship was anchored on the crest of the Santa Lucia Bank, hourly profiles of temperature and salinity were made down to 170 m. These data will be discussed in a separate report. The temperature profiles were quasi-isothermal and ranged around 13° to 14°C, but there was indication of abrupt time variations in temperature and salinity between 40 m and 140 m. These appear to be caused by horizontal advection of water sinking from the surface due to winter cooling elsewhere in the Ligurian Sea.

Current measurements were also made at 30 m and 110 m depths; the mean speed at 30 m obtained from 26 hourly averages was 24.0 cm/s, and the mean speed at 110 m depth (obtained from 23 hourly averages) was 20.6 cm/s. During this period the direction of flow was relatively steady to the west and west-southwest. During the week prior to the observations the local winds were light to moderate with no storm passages occurring. Thus, the observations are probably representative of the mean magnitudes (if not direction) of the prevailing current over the seamount.

Many individual and group acoustic scatterers were observed on the echo sounder sections made across the peak [Fig. 8]. It was further noted that an unusual amount of fish was caught by the ship's crew during the period at anchor. Diurnal depth fluctuation of the acoustic scatterers was observed.

Figure 8 indicates two types of acoustic scatterers. Larger fish or groups of smaller fish presumably produce the individual scatterers at from 20 m to 60 m depth. A cloudy band at 200 m to 220 m on the left of the peak and a very pronounced cloud echo on the right of the peak between 60 m and 200 m seem to be produced by large schools of fish. To explain this it is reasonable to assume that among the apparently large fish population there is a periodic migration of small fish (perhaps 3 cm to 10 cm long) between their

daytime depths of 200 m and 250 m and their night-time depth of 100 m to 50 m. Probably this is an instinctive action whereby during the day the small fish seek the protection of the deeper, darker depths. If, when they descend in the daytime, they happen to be above the plateau of the Bank, they remain trapped by the shallow bottom and become easy prey for larger predator fish 10 cm to 80 cm long (many of which were caught when the ship was at anchor). It is probably these large fish in the process of feeding that make the best scatterers on the echogram [Fig. 8]. Thus the top of this seamount becomes a rewarding hunting ground for the larger fish, who become quasi-permanent inhabitants and feed heavily during the night. This suggests that observations made over or near Santa Lucia Bank might provide us with important knowledge of sound scatterers in the Mediterranean.

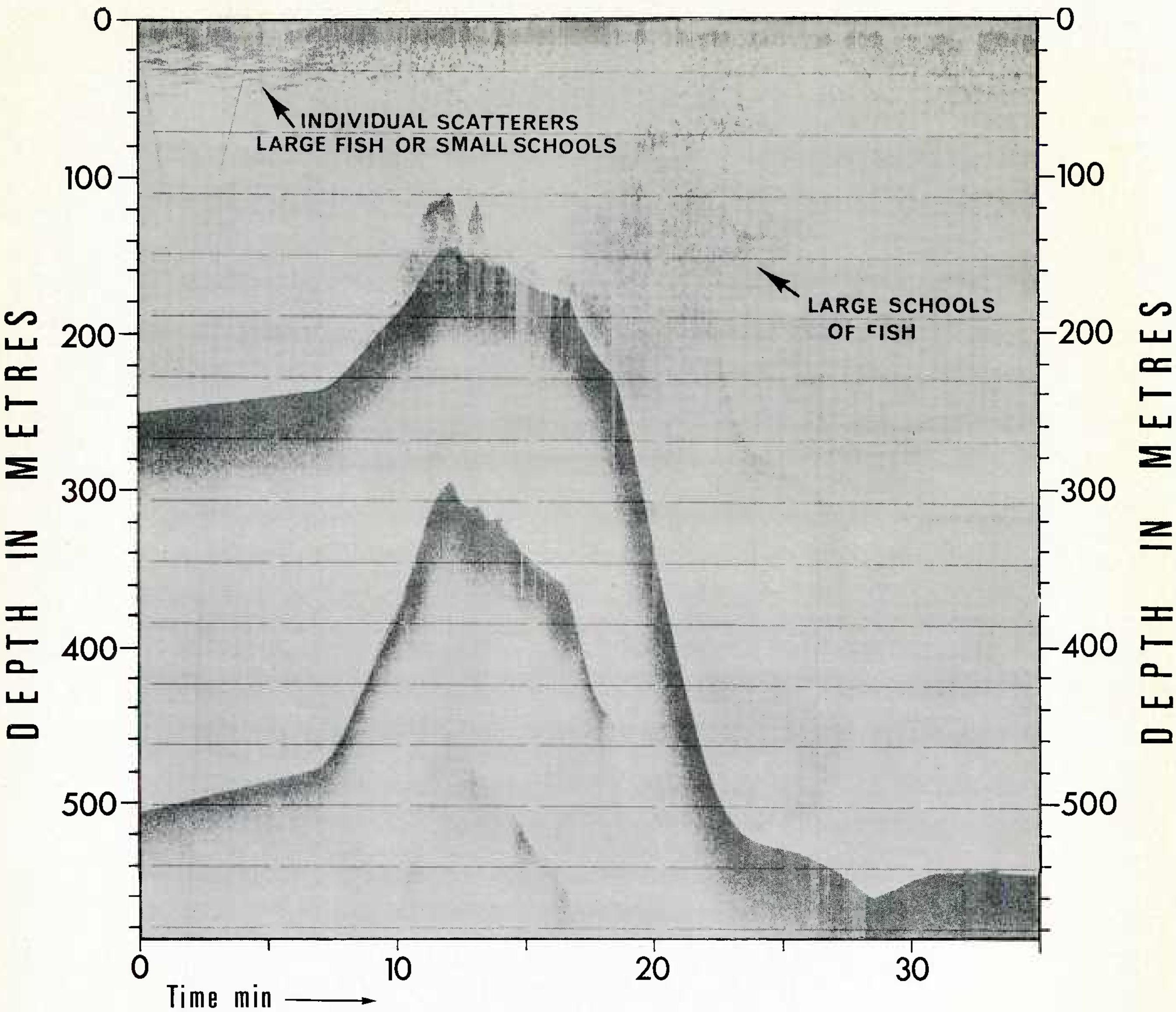

FIG. 8 SOUND SCATTERERS OBSERVED OVER THE SANTA LUCIA BANK

3. COMMENTS ON THE GEOLOGY OF THE BANK

A previous study of Santa Lucia Bank was made in 1955 when Orolan [Ref. 3] surveyed the area with a small bathyscaphe. The peak of the Bank was described as being made of hard rock protruding over a plateau covered with sand. According to Bourcart and Ottman [Ref. 3] the sand is exclusively made of skeletal remains (including Mollusca, Brachiopoda and corals). The thin sheet of sand (a few centimetres thick where it was sampled) was found to overlie — in the peak area — an organic limestone of Miocene ages (from 5 to 25 million years old).

A 6 kg sample of sand was obtained from the northwest region on the upper slope at about 250 m depth in August 1969 using a small clamshell grab from the MARIA PAOLINA G. Apart from the sand, about 1% to 2% of the grab sample weight consisted of fragments of coral and shells from a few millimetres to 10 cm in diameter. This part is referred to as the organic fraction: the remaining smaller fragments of coral and shells were analysed as an integral part of the sand sample. (It is realized that a single grab sample may not be completely representative of the debris over the whole Bank, but it should suggest the general material present.) The contents of the sample were as follows*:

Organic fraction:

Pelecypoda (Chlamis similis, Chlamis bruei, Arca aspera, and others which were broken and unidentifiable)
Gasteropoda (Danilia tinei and Emarginula cancellata) [Ref. 4]
Brachiopoda (Mergerlia disculus, Megatiris detruncata, and Terebratulina caput serpentis)
Coelenterata (Dendrophyllia cornigera)
Artropoda (unidentified debris)
Protozoa (pelagic forminifera)

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* The geological analysis was made possible by funds from the Italian Research Council. The help of Dr. Rossi of the Zoological Museum, Turin, is gratefully acknowledged for the specific determination of the coral fragments.

(All of the above species are living today in the Mediterranean.) Also found were many Pteropoda skeletons and one 4 mm long shark tooth.

<u>Inorganic fraction</u>:
The sand belongs to a metamorphic complex, basically comprising two rock types: "polished schist" and metamorphic ophiolite.

The rock from which the sand was derived is known to outcrop on west Corsica and on Gorgona Island (30 km SE of the Bank, as is shown in Fig. 1). Most probably in a large part of the Ligurian Sea this rock underlies a thin sedimentary cover that is probably not older than 20-25 million years. On the mainland it crops out in the western Alps and on the Apennines behind Genoa.

Our samples contained no fragments derived from the organic limestone mentioned by Bourcart and Ottman [Ref. 3], which indicates that this formation is not continuous in the area. Since the Bank is surrounded by relatively deep water the coarse sand found on its upper slopes was probably not transported from the mainland but rather was produced locally by the wave action on the once uncovered basement rocks. Evidence that the Bank was once uncovered is indicated by its morphology [Fig. 3]: for instance we see valleys, ridges and upper terracing, which are not likely to be produced in a marine environment at the present depth.

The frequency distribution of grain sizes in the grab sample (obtained by sieving and pipette analysis) is a polymodal curve [Fig. 9] whose shape is rather different from the size distributions found in modern beach sands [Ref. 4]. To further investigate this problem, a comparison was made between the statistics of normal beach sands [Refs. 5, 6 and 7] and those of the Santa Lucia Bank sample, as shown in Table 1. This comparison indicates:

a. The Santa Lucia Bank sand sample is coarser than most of the beach sands reviewed.

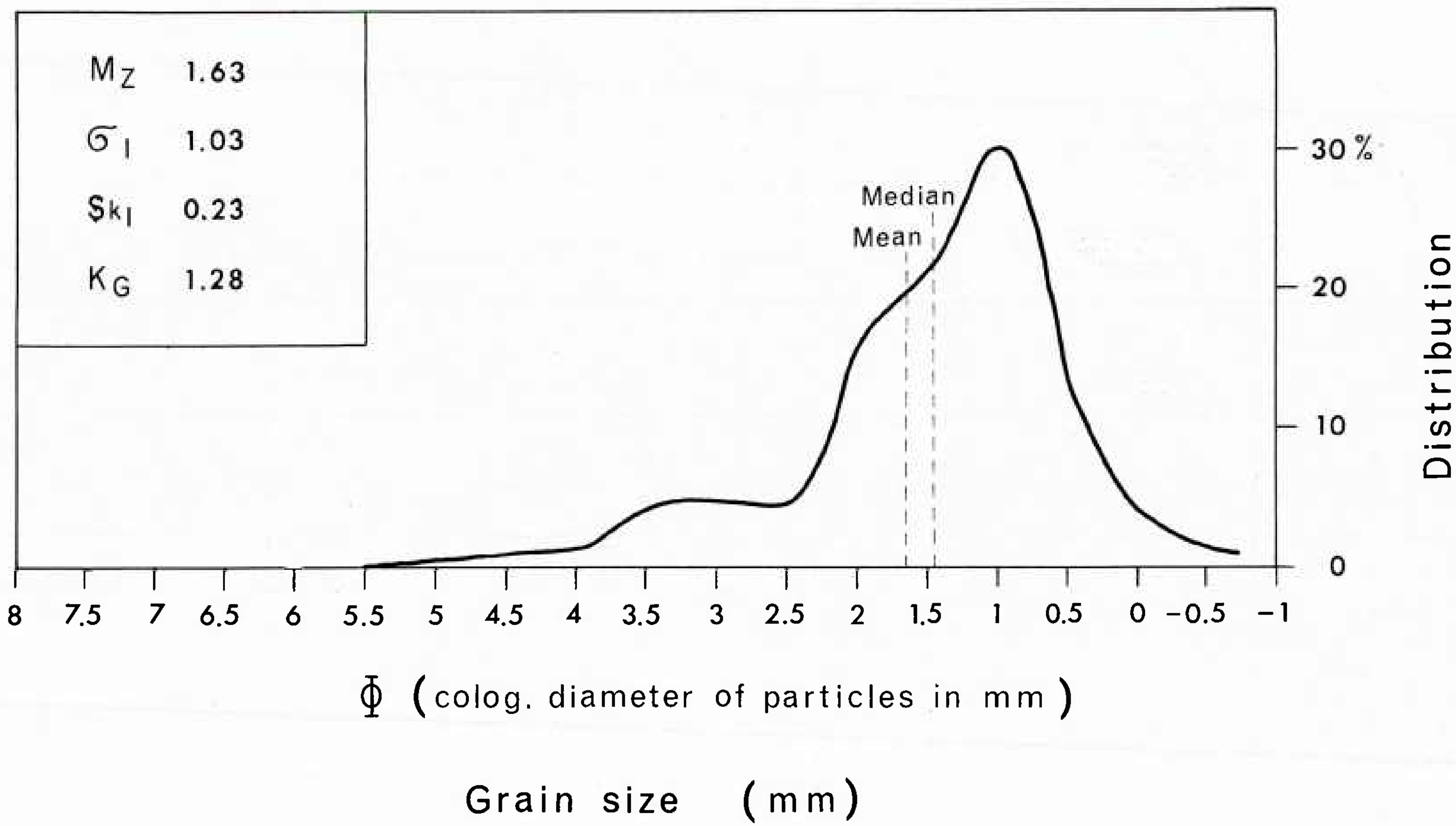

FIG. 9 THE GRAIN-SIZE FREQUENCY DISTRIBUTION CURVE OF THE GRAB SAMPLE FROM SANTA LUCIA BANK

TABLE 1

COMPARISON OF STATISTICS FROM BEACH SANDS & SANTA LUCIA BANK GRAB SAMPLE

Average Ranges	31 Samples - Mustang Is. Texas (Ref. 5)	80 Beaches Western Hemisphere (Ref. 6)	30 Beaches Florida (Ref. 7)	Santa Lucia Bank
Mean Diameter $M_z(\Phi)$ (mm)	+2.75 to +2.89	-	+1.7 to +2.1	+1.63
Sorting Coefficient σ_I	+0.3 to +0.35	+0.2 to -0.6	+0.2 to +0.45	+1.03
Skewness of Freq. Dist. Sk_I	-0.2 to +0.005	-0.3 to +0.3	-0.1 to +0.1	+0.23
Kurtosin of Freq. Dist. K_G	+0.97 to +1.25	+0.8 to +1.3	+0.9 to +1.2	+1.28

b. The sand is moderately to poorly sorted as compared with the beach sands, which are generally well sorted.

c. While the size frequency distributions of the beach sands are nearly symmetrical, that of the Santa Lucia Bank sand is positively skewed.

d. The kurtosis of the frequency distribution of the Santa Lucia sample is slightly larger than that of the normal beach sands.

Comments (b) and (c), together with the polymodal character of the frequency distribution curve, suggest the following sequence of events:

(1) During a relatively long period the Bank was partly uncovered and wave erosion on its beach produced sand, the finer fraction of which was transported out to deeper water and down the sides of the seamount.

(2) The island has been submerged during a relatively short period (perhaps over a few thousand years).

(3) Normal sedimentation added the finer sand fraction to the coarse sand in the upper regions of the seamount. This effect would produce the poorly sorted grain size distribution shown in Fig. 9.

No direct evidence can be drawn from the studied sample to estimate accurately how long ago the Bank was uncovered. The drop in sea level during Pleistocene glaciations has been variously quoted to be from 150 m to 200 m [Ref. 8]. Even if the seamount itself has not experienced recent sinking, this drop in sea level would have uncovered from one to six square kilometres. It is suggested that a large part was uncovered until at least the Mendel glacial age (from 7 to 8 million years ago).

CONCLUSIONS

From this brief description of the Santa Lucia Bank it appears that this small seamount would be a good place to conduct certain oceanographic, sea/air interaction, and possibly acoustic, observations, for the following reasons:

1. The seamount is shallow and the currents passing over it appear weak enough to permit a vessel and/or instrumented buoy platforms (both of surface and subsurface variety) to be anchored to a permanently placed mooring at its crest.

2. The seamount's distance from land means that the meteorological and oceanographic environment would tend to be characteristic of "open sea" conditions.

3. The large fish population around the seamount provides a relatively predictable environment in which to observe properties of acoustic scatterers.

4. The proximity of Santa Lucia Bank to SACLANTCEN (4 hours steaming at about 10 knots) allows easy and quick access to this region. There is also the possibility of anchoring observation platforms from which oceanographic, acoustic or meteorological data could be radioed to SACLANTCEN. Furthermore, knowledge of the seamount's oceanographic environment could easily be increased by modest samplings made by the MARIA PAOLINA G. on passage to and from other cruises.

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